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Training Simulant for Halon 1211 Portable Extinguishers

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Hughes Associates, Inc.
Columbia, MD

September 8, 1994

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The Standard Navy portable Halon 1211 extinguisher can be modified to provide an environmentally acceptable simulant for training. The modifications include replacement of the Halon 1211 with pressurized water as the fire fighting agent and insertion of a full cone spray nozzle in the horn of the extinguisher to form a suitable spray pattern. The modified extinguisher has the same physical appearance and discharge characteristics (time, reach, etc.) as the standard Halon 1211 extinguisher and weighs just two pounds less. Since it uses water as the fire fighting agent, the trainng simulant has zero Ozone Depletion Potential, zero Global Warming Potential and is non-toxic. Also, there is a potential savings of $160,000-$190,000 per year, based on a usage of 20,000 lbs/year of Halon 1211 for training.

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BACKGROUND

Halon 1211 portable extinguishers are a vital part of the Navy's flight deck fire fighting strategy. All flight deck crash and rescue teams receive training in the use of Halon 1211 portable extinguishers on the specialized aircraft fire fighting training devices at the Naval Air Technical Training Center (NATTC), Millington, TN. The total amount of Halon 1211 used in these training evolutions can be as much as 20,000 lbs per year. However, the production of Halon 1211 was phased out in January 1994 under adjustments to the Montreal Protocols which were approved in Copenhagen last year. Accordingly, efforts have been undertaken within the Navy to conserve existing supplies of Halon 1211 for fire fighting applications only. For example, the Naval Air Systems Command (PMA-205) tasked the Naval Research Laboratory (NRL) to develop a replacement for Halon 1211 for flight deck fire fighting training. The replacement agent was required to have the same physical appearance, discharge characteristics (time, reach, etc.) and weight as the current shipboard Halon portable extinguisher and be capable of being discharged from the current extinguisher. It was not required that the replacement agent extinguish the fire as effectively as Halon 1211, since all of the training fires at Millington are spray fires which are turned off by the instructor once he is convinced that the student has the proper technique.

OBJECTIVE

The objective of the current study was to determine if pressurized water could be used as a simulant for Halon 1211 in the Standard Navy portable extinguishers for flight deck firefighting training.

PROCEDURE

The procedure consisted in first determining the discharge characteristics of the standard Navy Halon 1211 portable extinguisher using Halon 1211 as the agent and then modifying the extinguisher in such a way as to produce similar discharge characteristics using water as the agent.

The standard Navy Halon 1211 portable extinguisher, as shown in Fig. 1, contains 9 kg (20 lb) of Halon 1211. The discharge

Manuscript approved July 27, 1994.

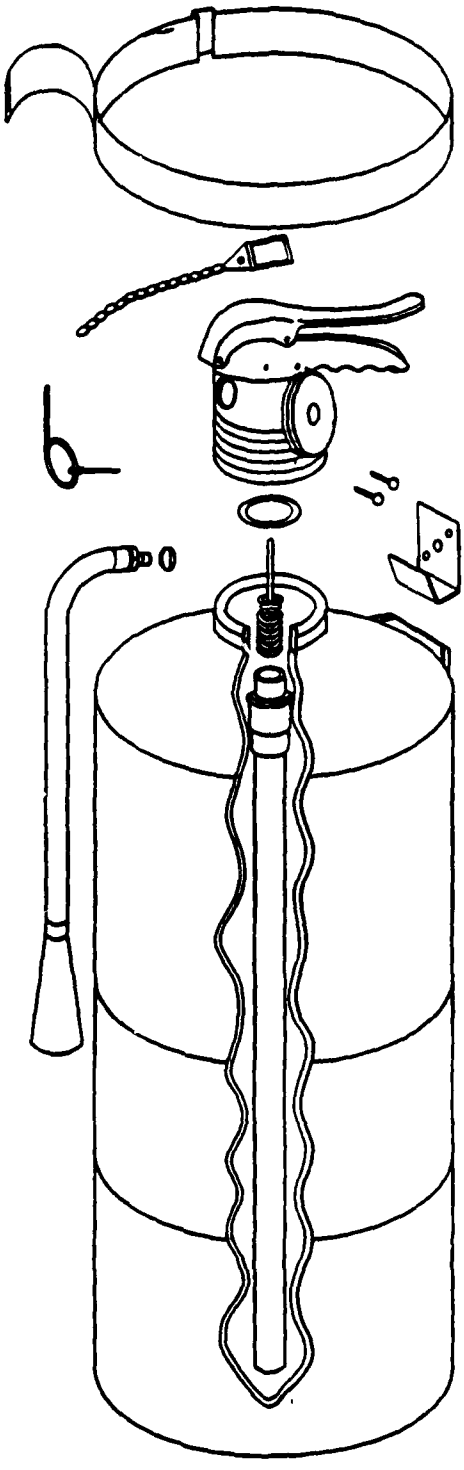

Fig. 1 - Halon 1211 (simulant) extinguisher with hose and horn (Model 372, 9 kg (20 lb))

characteristics of this unit were determined by discharging the extinguisher and photographing the discharge pattern against a scaled background. From these tests, the discharge time, throw distance and spray pattern were established.

Then, a series of tests was conducted in which the Halon was replaced with water and the extinguisher pressurized with nitrogen to 1340 kPa (195 psi). Other modifications included:

a. Insertion of screws in the horn of the extinguishers to break up the water stream.

b. Replacement of the nozzle with other commercially available nozzles to optimize the discharge characteristics. All of the nozzles tested were made by the Bete Fog Nozzle Co. of Greenfield MA and are listed in Table 1.

Table 1 - Nozzles Tested

Model	Description	Flow Rate (Lpm (gpm))	Pressure kPa (psi)
TF8FC	Pig tail	25 (6.6)	1379 (200)
WL3120	Whirl plate, 120° full cone with a 0.396 cm (0.156 in.) diameter orifice	25 (6.6)	1379 (200)
WL330	Whirl plate, 30° full cone with a 0.358 cm (0.141 in.) diameter orifice	25 (6.6)	1379 (200)
NF3000	Fan nozzle, 0°	25 (6.6)	1379 (200)
NF3015	Fan nozzle, 15°	25 (6.6)	1379 (200)
Standard horn with two screws	Inserted in the base of the horn	25 (6.6)	1379 (200)

The effectiveness of the pressurized water training simulant was then compared with Halon 1211 in a series of fire tests using mock-ups of two of the fire fighting training devices used at Millington, namely the engine fire and the cascade fire.

RESULTS

First Series - Testing Outdoors

It was established from the Halon discharge tests that the discharge time for the 9 kg (20 lb) portable was about 22 seconds and the throw distance ranged from 5.8 - 6.7 m (19 - 22 ft) for approximately eight seconds, then dropped off to about 4.2 m (14 ft) until the extinguisher was discharged. The spray pattern did not mist extensively and there was considerable fallout of 1211 droplets.

The effect of elevated temperatures on the discharge of Halon 1211 was checked by placing an extinguisher in a water bath of 32°C (89°F) for about an hour. The discharge time did not change, but the throw distance was greatly reduced as the halon misted and vaporized rapidly with far less drop fallout.

The extinguisher was then filled with various quantities of water, pressurized with nitrogen to the standard pressure of 1340 kPa (195 psi) and the discharge characteristics recorded. The results of these tests are summarized in Table 2. When the unmodified extinguisher was tested with water (Tests 2-9), the flow rate was greater than desired and the discharge pattern did not resemble Halon 1211. The discharge pattern was then modified by inserting 2 or 4 screws in the extinguisher horn. It was found that using two screws improved the discharge pattern (Tests 5,6 and 8), while four screws (Test 7) caused excessively large droplets and therefore was unsatisfactory.

The hose and cone assembly of the Halon extinguisher were then modified to accommodate the various Bete nozzles. The performance of the pig tail nozzle (TF8FC), which produced large droplets, and the whirl plate (WL3120), which created excessive mist, were both considered unsatisfactory - see Tests 10 and 11.

Second Series

Due to strong winds of about 24 km/h (15 mph), the second series of testing had to be done inside. Tests 12 - 15 used the three remaining Bete nozzles and 35.2 kg (16.0 lb) of water in the extinguisher. Tests 12 and 13 used the whirl nozzle (WL330) which is a 30° full cone nozzle with a 0.358 cm (.141 in) diameter orifice. This nozzle had the best discharge appearance so far, but still did not mist as extensively as desired. Test number 14 used the NF3015 nozzle with a 0.368 cm (0.145 in) diameter orifice which did not produce enough mist and had excessive throw distance. Test 15 used a cross cut (NF3000) Bete nozzle. This nozzle produced a straight stream with a throw distance of 7.7 m (25 ft). Test 16 was a side-by-side comparison of the WL330 nozzle with a standard Navy portable Halon 1211 extinguisher. The temperature of the Halon was at about 18°C (65°F) and the agent was vaporizing. The

Table 2 - Evaluation of Modified Halon 1211 Extinguishers Using Water

Test No.	Water Fill Weight	Nozzle Configuration	Miscellaneous Comments
First Series - Testing Outdoors			
2	15.6 kg (34.3 lb)	Standard	Throw rate 5.7-6.1 m (19-20 ft) to 4.3-4.6 m (14-15 ft)
3	4.4 kg (9.7 lb)	Standard	Throw rate 7.6-9.1 m (25-30 ft) to 5.7-6.1 m (19-20 ft)
4	6.5 kg (14.3 lb)	Standard tape	Throw rate 7.9-8.5 m (26-28 ft) to 5.7-6.1 m (19-20 ft)
5	6.2 kg (13.6 lb)	Standard with 2 screws	Throw rate 5.5-6.1 m (18-20 ft) to 4.3-4.6 m (14-15 ft) – good
6	7.4 kg (16.3 lb)	Standard with 2 screws	Throw rate 6.1-7.6 m (20-25 ft) to 4.6-5.5 m (15-18 ft)
7	7.5 kg (16.5 lb)	Standard with 4 screws	Water droplet size too large
8	7.5 kg (16.5 lb)	Standard with 2 screws	1211 side-by-side satisfactory
10	7.4 kg (16.3 lb)	TF8FC	Did not mist large droplets
11	7.4 kg (16.3 lb)	WL3120	No video
Second Series - Testing Indoors			
12	7.3 kg (16.0 lb)	WL330	Best discharge appearance but too much distance
13	7.3 kg (16.0 lb)	WL330	Good mist, too much distance (7.6 m (25 ft))
14	7.3 kg (16.0 lb)	NF3015 test	Not enough mist, too much distance (7.6 m (25 ft))
15	7.3 kg (16.0 lb)	NF3000 (cross) test	Straight stream distance (7.6 m (25 ft))
16	7.3 kg (16.0 lb)	WL330	1211 (18°C (65°F)) side-by-side
17	6.4 kg (14.0 lb)	WL330	Excellent, comparable to halon
18	6.4 kg (14.0 lb)	WL330	Excellent, comparable to halon

water stream looked good initially, but as the pressure in the extinguisher dropped, there was less stream break up. Also, the water discharge time was too long.

To reduce the discharge time and maintain a higher pressure in the extinguisher, the amount of water was reduced in Test 17 to 30.8 kg (14.0 lb), creating a greater head space. The discharge time was brought down to the required 23 seconds, and the stream maintained its appearance throughout the majority of the discharge period, falling off only at the very end. This appeared to provide a very good approximation of the Halon 1211 discharge.

Test 18 was the same as Test 17 except that it was run outside with a slight cross wind of 6-8 knots blowing with the extinguisher discharge, as is the case during actual training and use. The discharge spray still looked good, but the spray was blown around by the wind (as is expected with Halon 1211) thereby reducing the stream reach. In general, the appearance of the water discharge was very similar to the discharge of Halon 1211 particularly at lower temperatures, and was also very similar to the higher temperature discharge of Halon 1211 before the stream starts to vaporize significantly and break into a fine mist.

Live Fire Testing

The final phase required the evaluation of the pressurized water simulant under the same controlled conditions as used at the school house. To accomplish this, mock-ups of the training devices used at NATTC Millington for portable fire extinguisher training were constructed and installed at NRL's Chesapeake Bay Detachment (CBD) fire test facility.

The installation to simulate the aircraft engine tailpipe fire device initially consisted of a single 55 gallon drum attached to a stand using a TF-10 spiral nozzle to spray the fuel (Fig. 2). A second barrel was attached to the first barrel after the initial set of tests to better approximate the actual device.

The installation to simulate the cascade fire device consisted of a 1.2 x 2.1 m (4 x 7 ft) steel plate with a fan nozzle at the top and a TF10 spiral nozzle at the bottom, as in the real device (Fig. 3).

A constant fuel pressure of 206 kPa (30 psi) was used throughout the live fire test phase, to duplicate that used in the NATTC Millington devices. Other features of the simulated training devices at CBD included:

a. Same spray fuel nozzles working at the same pressure as real devices;

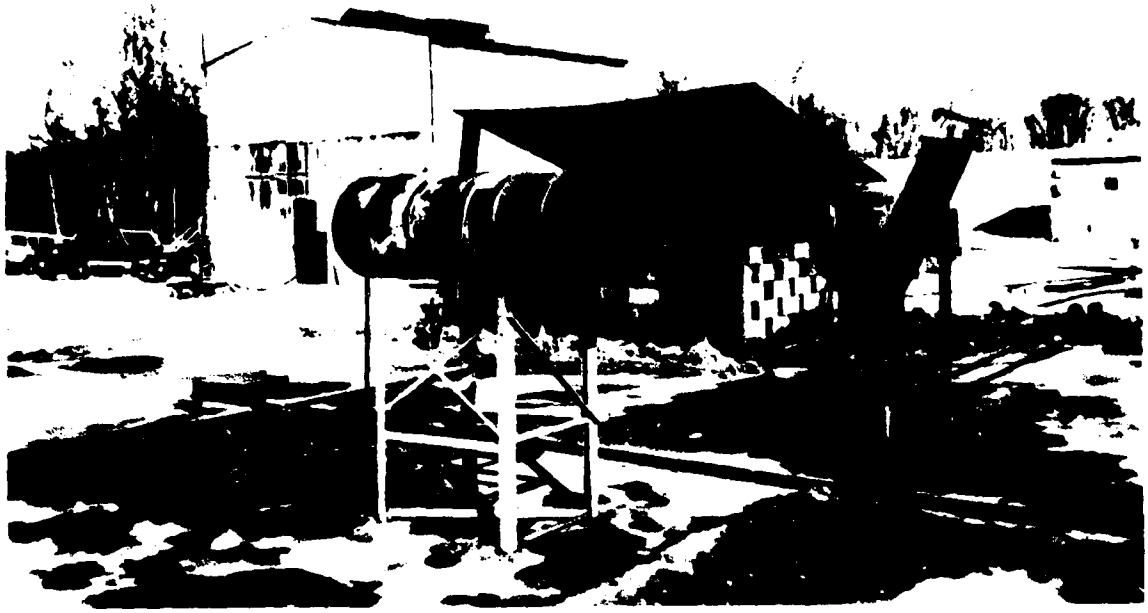

Fig. 2 - Aircraft engine tailpipe fire test device

Fig. 3 - Cascade fire test device

b. Same type 1/4 turn fuel activation/shut-off valves as real devices;
c. Spray fuel activation, ignition, and shutdown sequencing the same as real devices (except ignition being manual); and
d. Firefighter approach and agent application the same as taught in training.

An additional goal was to evaluate the ability of the water simulant to extinguish residual fires which may occur at the base of or behind the training device.

The results of the live fire tests are given in Table 3. The initial set of tests, Tests T-1 - T-6, were conducted to familiarize the spray fuel valve operator with the correct valve closure sequence procedures. Additionally, these tests also allowed firefighters to become familiar with correct approach and agent application procedures.

In Test 19 - 47, the final water simulant configuration was compared with Halon 1211. These tests were conducted using a Halon portable extinguisher charged with 9 kg (20 lbs) of Halon and a second Halon extinguisher modified as follows:

a. Hose and Horn Nozzle Assembly were modified by removing the original orifice from the horn nozzle and placing a (WL330) spray nozzle into the base of the horn nozzle assembly A 0.953 x 0.10 cm (0.375 x 0.25 in.) standard pipe-thread bell reducer and a standard pipe-thread 0.10 x 10 cm (0.25 x 4 in.) piece of pipe were used to make this connection. This nozzle assembly (Fig. 4,5 and 6) was then inserted into the base of the horn nozzle and hose assembly and clamped;

b. 6.62 ℓ (1.75 gal.) of water was used in place of Halon 1211;

c. Extinguisher was pressurized to 1340 kPa (195 psi).

A side by side comparison of the discharge characteristics of the modified extinguisher with the standard Navy portable Halon extinguisher is shown in Fig. 7. As indicated in the figure, the discharge characteristics of the two extinguishers are remarkably similar.

Tests 37 through 47 were a series of fire extinguishment tests on the engine and cascade fire devices comparing Halon 1211 and the water simulant. On the engine device fires, the water simulant (Figs. 8 and 9) looked and affected the fire the same as Halon

Table 3 - Live Fire Tests

Test No.	Test Purpose and Device	Agent	Comment
T-1 - T-6	Spray fuel VLV operator and firefighter familiarization engine/cascade device	Water simulant	Spray fuel VLV closure sequence and firefighting procedures the same as training.
19-21	Live fire test continued engine fires Live Fire Test continued Cascade Fires	Water simulant Water simulant	Firefighting procedures, valve closure sequence and extinguishment time, effect, and appearance looked good.
22-31	Live fire test continued cascade fire device	Water simulant	Firefighting procedures, valve, closure sequence proficiency took a little longer extinguishment time 2-3 seconds longer effect and appearance look good.
32-36	Replaced lower nozzle with fan type same as top to evaluate cascade device	Water simulant	Fan nozzle on bottom of device spreads fire too far up device.
37-39	Returned lower nozzle to a TF10 spiral configuration to commence the comparison testing	Test #40 halon Test #41-44 water simulant	Simulant looked and affected fire same as halon and extinguish time was comparable to halon. One extinguisher used for four fires same as actual training.
40-44	Final comparison tests with halon and water simulant engine devices	Test #40 halon Tests #41-44 water simulant	Simulant looked and affected fire same as halon and extinguish time was comparable to halon. One extinguisher was used for four fires same as actual training.
45-47	Final comparison tests with halon and water simulant cascade device	Test #45 halon Tests #46-47 water simulant	Water simulant was comparable with halon. The 2-3 second difference in extinguishment time is considered negligible from a student standpoint.
D1 - D5	Pan fire demo for NAVAIR to show halon will extinguish while water simulant will not	Test #D1 halon Test #D2 simulant Test #D3 halon Test #D4-5 simulant	The water simulant is not designed for use on real fires in the field.
D6 - D9	Demo for NAVAIR halon and simulant comparison on engine fire device CBD	Test #D6 halon Test #D7 simulant Test #D8 halon Test #D9 simulant	Demo showed that water simulant is comparable to halon when used in a training scenario.
D10 - D13	Demo for NAVAIR halon and simulant comparison on cascade fire device CBD	Test #D10 halon Test #D11 simulant Test #D12 halon Test #D13 simulant	Demo showed that water simulant is comparable to halon when used in a training scenario.

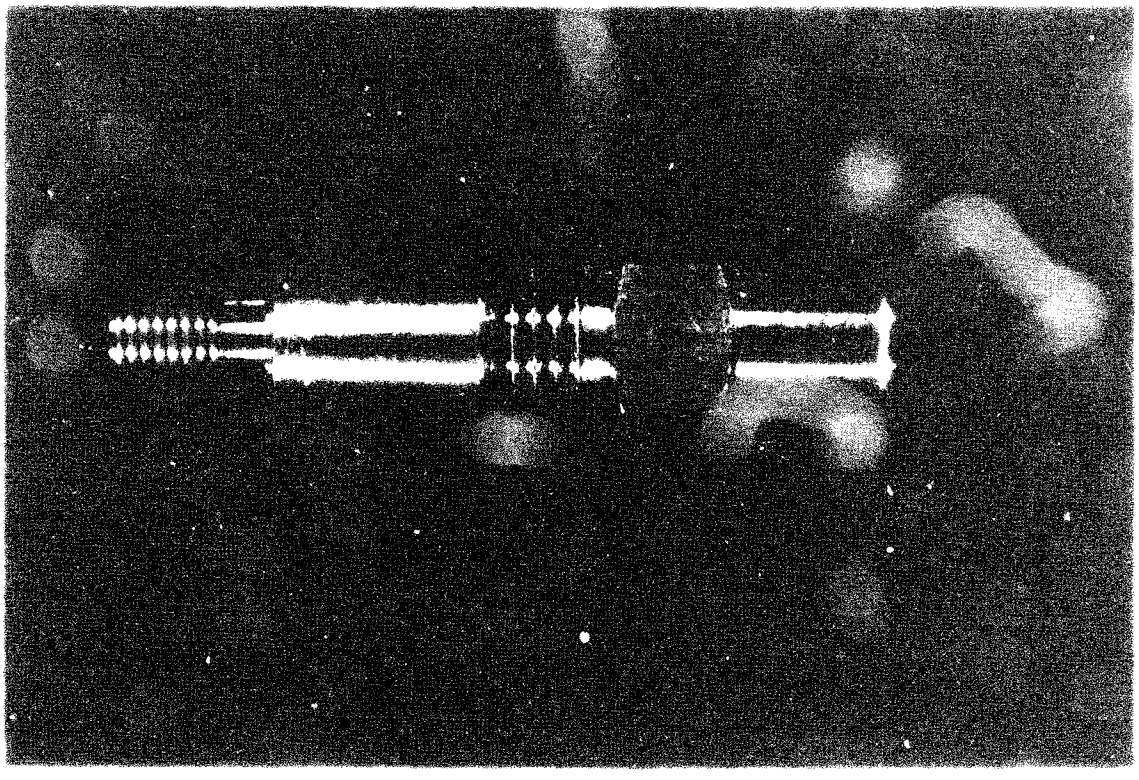

Fig. 4 - Side view of final nozzle assembly

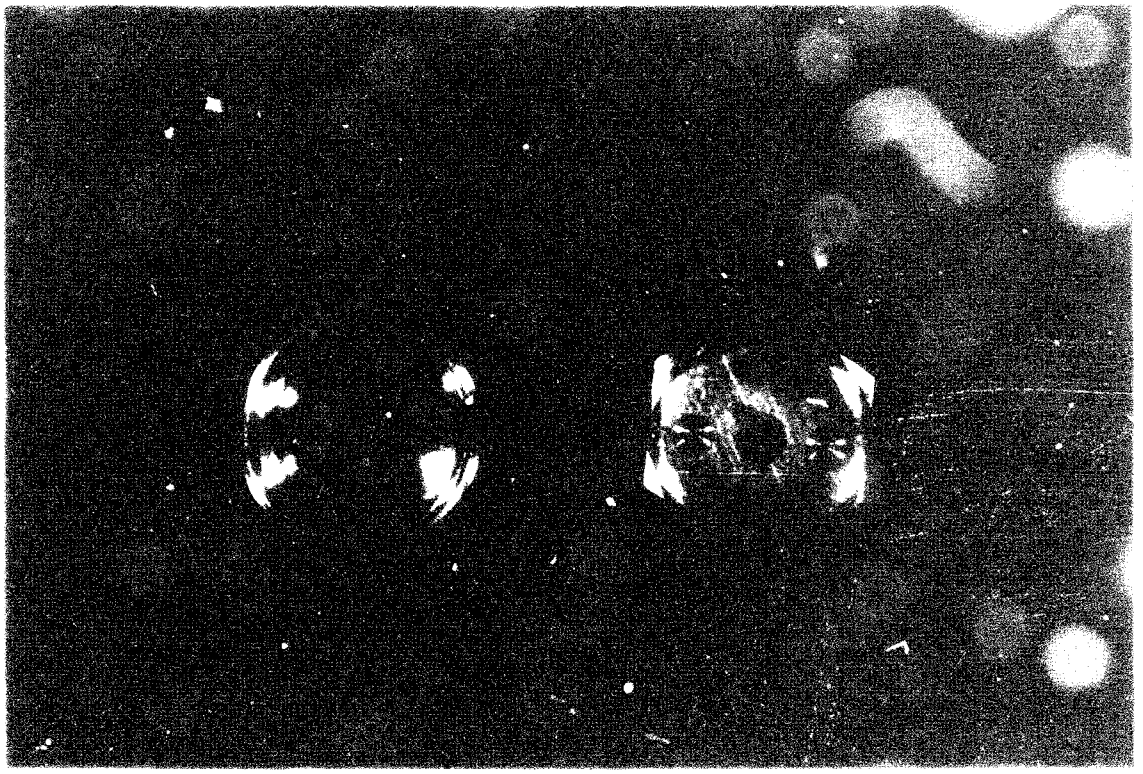

Fig. 5 - Front view of nozzle and adapter

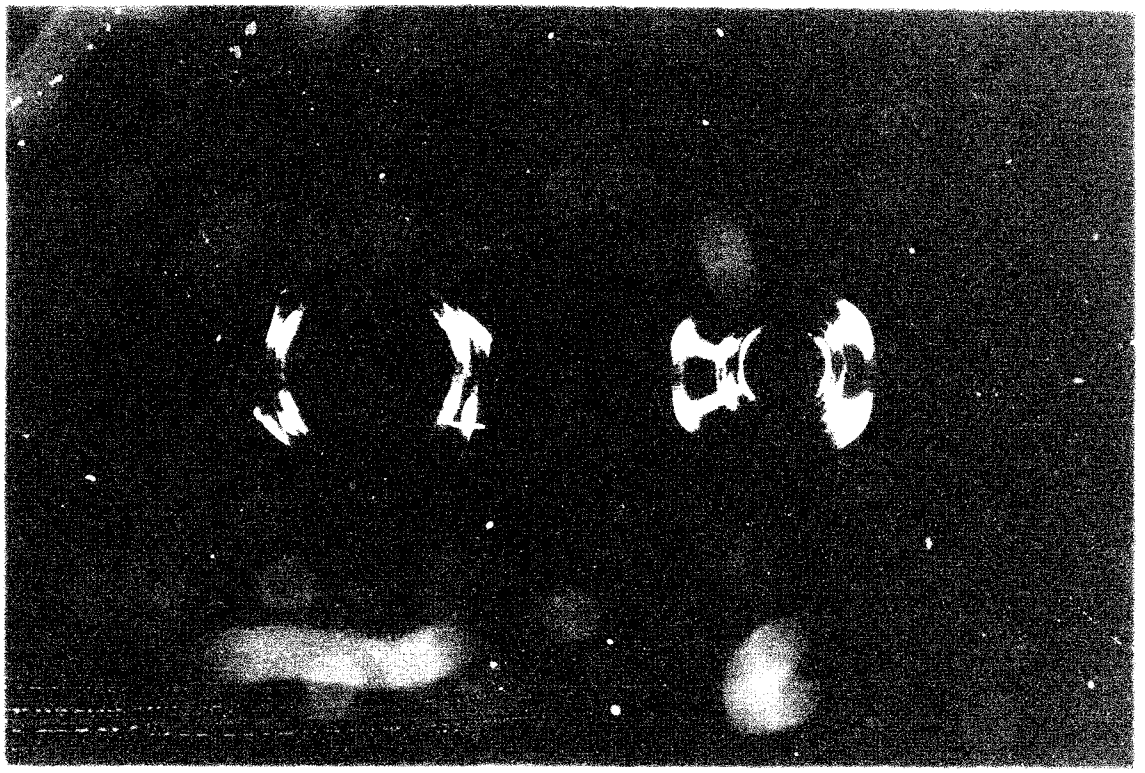

Fig. 6 Rear view of nozzle and adapter

Fig. 7 - Halon 1211 upper, water simulant lower, side-by-side

Fig. 8 - Engine fire test using water simulant (initial attack)

Fig. 9 - Engine fire using water simulant (attack complete)

(Figs. 10 and 11). The "extinguishment time"* was comparable to Halon and one modified portable extinguished four (4) complete fires with a single charge. On the cascade device fires, the water simulant (Figs. 12 and 13) discharge appearance and effect on the fire were comparable to Halon (Figs. 14 and 15). The "extinguishment time" was 2 to 3 seconds longer than Halon and one modified portable extinguisher extinguished three (3) complete fires with a single charge plus residual fires on the surface surrounding the cascade device.

The results of these tests demonstrated that:

a. Water simulant discharge rate and spreading pattern are comparable to Halon as firefighter approaches a fire;

b. Discharge vaporization (i.e., the appearance of the simulant) was comparable to Halon;

c. "Extinguishment time" on the engine fire was comparable to Halon;

d. "Extinguishment time" on the cascade fire was only two to three seconds longer;

e. The effect of the simulant on both the engine and cascade fires were comparable to Halon with the exception that the residual smoke after fire was out was white, instead of black/grey;

f. The ability of the simulant to extinguish a small amount of residual fire was considered satisfactory;

g. Overall weight of a fully charged simulant filled extinguisher is 14 kg (32 lb) making it 0.9 kg (2 lb) lighter than the fully charged Halon 1211 extinguisher.

CONCLUSION

The standard Navy portable Halon 1211 extinguisher can be modified to provide an environmentally acceptable simulant for training. The modifications include replacement of the Halon 1211

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* - N.B. - "extinguishment time" in quotes refers to the apparent extinguishment time of the water spray. It does not imply that the water spray actually extinguished the fire, but rather that the fire was knocked down to the point that it appeared to have been extinguished by the water spray, which is sufficient for training purposes.

Fig. 10 - Engine fire test using Halon 1211 (initial attack)

Fig. 11 - Engine fire test using Halon 1211 (attack complete)

Fig. 12 - Cascade fire test using water simulant (initial attack)

Fig. 13 - Cascade fire test using water simulant (attack complete)

Fig. 14- Cascade fire test using Halon 1211 (initial attack)

Fig. 15 - Cascade fire test using Halon 1211 (attack complete)

with pressurized water as the fire fighting agent and insertion of a full cone spray nozzle in the horn of the extinguisher to form a suitable spray pattern. The modified extinguisher has the same physical appearance and discharge characteristics (time, reach, etc.) as the standard Halon 1211 extinguisher and weighs just 0.9 kg (2 lb) less. Since it uses water as the fire fighting agent, the training simulant has zero Ozone Depletion Potential, zero Global Warming Potential and is non-toxic. Also, there is a potential savings of $160,000 - 190,000 per year, based on a usage of 20,000 lbs/year of Halon 1211 for training, by using the training simulant.

The 0.9 kg (2 lb) difference in weight between the fully charged simulant extinguisher 14 kg (32 lb) versus 15 kg (34 lb) for the Halon 1211 extinguisher is insignificant since it would not be detected by the user. Additionally, the question of extinguisher longevity due to corrosion should not be a concern as long as an extinguisher is thoroughly cleaned and dried-out prior to introducing water or Halon. Only if Halon and moisture become mixed is corrosion a concern.

Use of water simulant extinguishers to train students in the proper tactics and agent application during live fire training scenarios can be successful when that training is conducted in a controlled environment as described in this report. However, it must be borne in mind that the water spray extinguisher is a training device *only* and should not be used for actual firefighting. Bands indicating for "TRAINING ONLY" have been placed on the extinguisher hoses to emphasize this point.

IMPLEMENTATION

The Adapter design (Appendix A) and WL330 nozzle modification requirements (Appendices B and C) were forwarded to Bete Fog Nozzle Inc. of Greenfield MA for manufacture and initial delivery of 150 adapters and 150 modified WL330 assemblies.

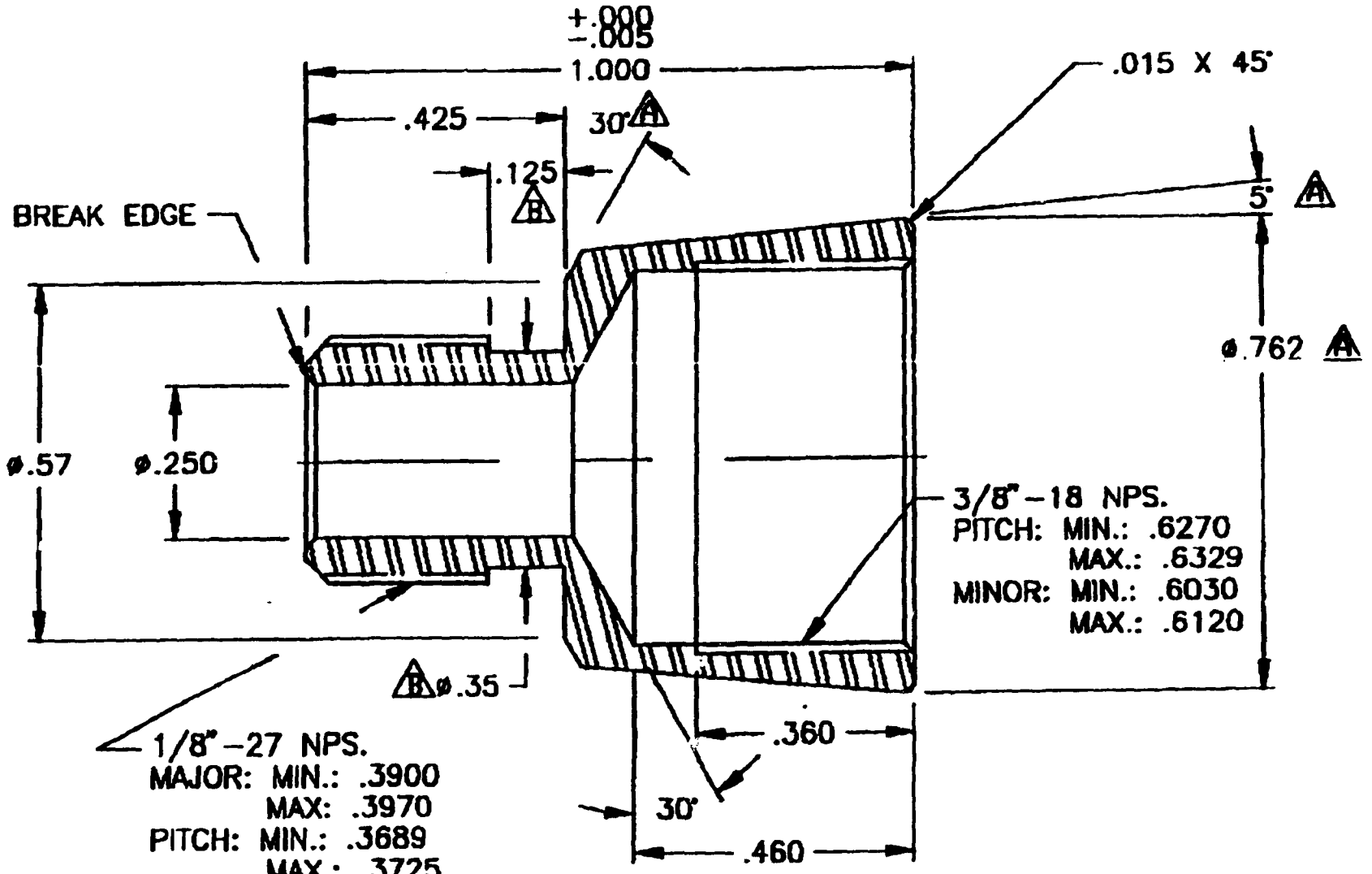
On September 16, 1993 the full complement of 86 modified, ready-to-install hose and horn assemblies were shipped to NATTC Millington TN. This shipment included the following:

(a) Navy complement of 58 plus 8 spares for a total of 66; and

(b) Marine complement of 17 plus 3 spares for a total of 20.

The first class usage of the water simulant extinguishers at NATTC Millington, TN aircraft fire schools was during the week of September 20, 1993. The water simulant performed as tested and demonstrated with no degradation to training.

During the week of September 27, 1993, An additional order for 75 modified hose and horn assemblies was placed to meet NAVAIR desires to provide ready for installation assemblies to other aircraft fire training activities as shown in Appendix D. Recharge procedures for the water simulant extinguishers were developed to support the delivery to the Fleet (Appendix E).



APPENDIX A

MAT'L.: BRASS.

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A	9.14.93	JS		4553

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TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
CAST DIMENSIONS: OVER 3" ±.01 INCHES PER INCH

BETE FOG NOZZLE, INC.
GREENFIELD, MASS.

1/8" NPS X 3/8" NPS ADAPATER

FOR

SCALE:	DRAWN: JS	CHECKED:	REV.
4 = 1	DATE: 9.14.93	DATE:	B

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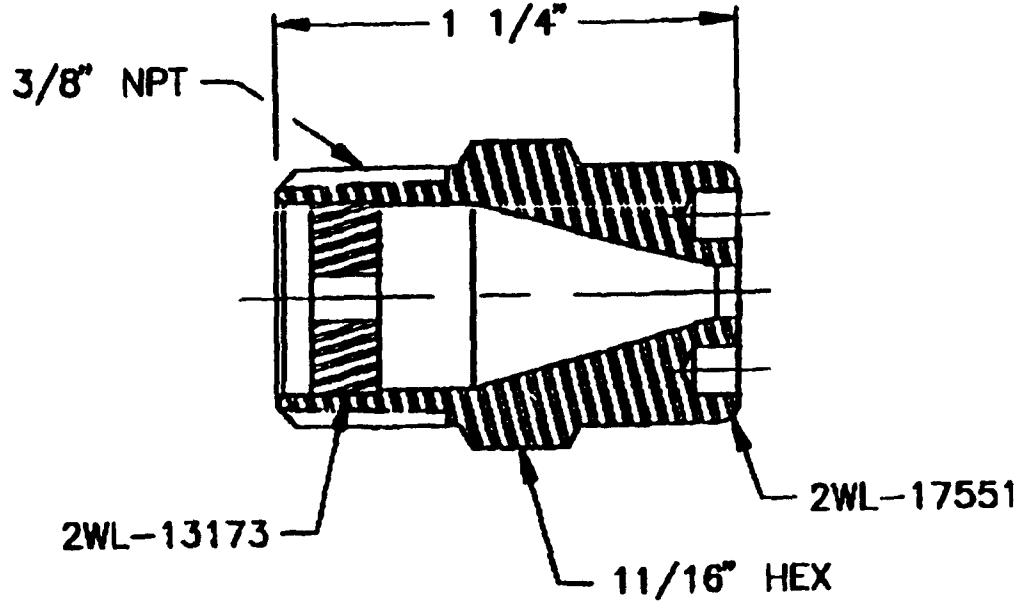

NOTES

1. MAT'L.: BRASS.
2. FLOW RATE: 3.0 GPM @ 40 PSI.
3. SPRAY PATTERN: 30° FULL CONE.

SHEET 2 OF 2

BETE FOG NOZZLE, INC.
GREENFIELD, MASS.

SPEC. 3/8" WL-3 30.(AS)
WITH WRENCH HOLES
FOR HUGHES

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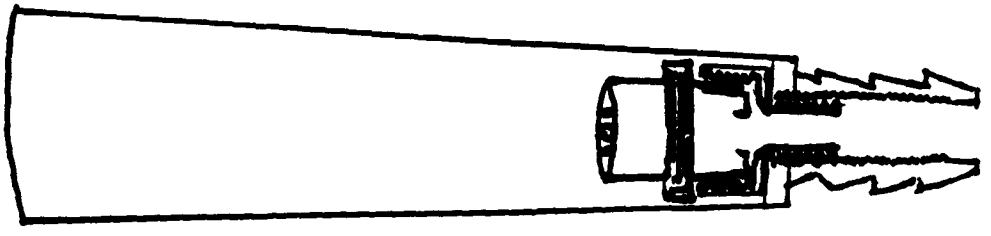
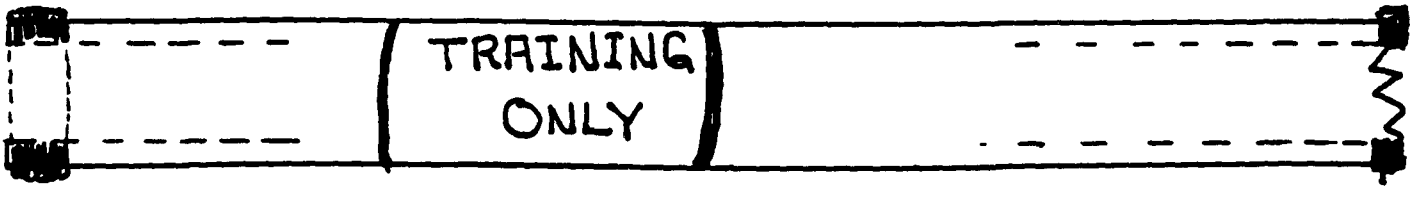
APPENDIX B

Bete Fog Nozzle Inc.
Spec. 3/8-in. WL-330(AS) Nozzle with Wrench Holes

HORN MODIFICATION



HOSE MODIFICATION



APPENDIX C

	LOCATION	QTY
(a)	Firefighting school, San Diego, CA	20
(b)	Firefighting school, NAS Lemore, CA	10
(c)	Firefighting school, NAS Whidbey, WA	10
(d)	Firefighting school, NAS Mayport, FL	10
(e)	Firefighting school, Norfolk, VA	20
(f)	Firefighting schools, Beaufort, NC Quantico, VA and other Marine Corps schools	33
(g)	NRL Chesapeake Bay Division (CBD) Fire Facility	1
(h)	Firefighting school, NATTC Millington, TN	86
(i)	NAVAIR PMA-251 spares	26
	Total	216

APPENDIX D

Halon 1211 9 kg (20 lb) Portable Training Extinguisher

Halon Simulant (H_2O) Recharge Procedures

CAUTION

Prior to introducing water into any previously Halon 1211 filled extinguisher, the cylinder interior and all key hardware components must be thoroughly cleaned with a detergent agent and hot water, or by steam cleaning.

EQUIPMENT REQUIRED

1. 3.8 cm (1.5 in.) adjustable end wrench or deep socket (for use on the Fill Connection Fitting).
2. Silicone grease (for use as an O-ring lubricant).
3. Extinguisher fill connection fitting with a *Male Quick-Disconnect fitting* attached.
4. Female quick disconnect fitting for nitrogen bottle/compressed air hose.
5. Nitrogen cart/bottle or compressed air unit/bottle with currently (calibrated) pressure reducing gage (set at 1340 kPa (195 psi) maximum).
6. Medium size funnel (ensure funnel spout has air grooves).
7. Water container with 6.62 L (1.75 gal) capacity or a container pre-marked to receive exactly 6.62 L (1.75 gal).
8. Spare O-rings for hose assembly threaded connection, discharge assembly threaded connection and for fill connection fitting.
9. Spring clamp for extinguisher discharge handle (to ensure all pressure is released prior to removal of discharge assembly).
10. Rags for cleanup.

9 kg (20 lb) Halon 1211 Simulant Training Extinguisher Refill Procedures

STEP #1: Depress discharge handle, attach spring-loaded clamp (to ensure all pressure is expended).

> **CAUTION**
>
> Attempting to remove the discharge assembly while pressure remains in the extinguisher can result in serious injury.

STEP #2: Remove hose and horn assembly and attach fill connection fitting (hand snug).

STEP #3: Remove spring-loaded clamp then remove discharge assembly from the extinguisher.

STEP #4: Visually inspect internal threads inside extinguisher discharge opening (lightly coat with lubricant).

NOTE: Internal and external threads in both the extinguisher and the discharge handle assembly. Shall be checked for wear using a thread-depth gage at a minimum on a quarterly basis.

STEP #5: Place funnel into extinguisher discharge opening (ensure funnel spout has air discharge grooves).

STEP #6: Fill water container with 6.62 L (1.75 gal) of fresh tap water and pour into extinguisher.

STEP #7: When all water is discharged from refill container, remove funnel and place both in a clean area.

STEP #8: Visually inspect the discharge handle assembly and external threads for wear. Visually check the O-ring for distortion, nicks or cuts (lubricate or replace as necessary).

STEP #9: Re-attach the discharge handle assembly to the extinguisher until hand tight.

STEP #10: Visually check nitrogen bottle or air bottle pressure gage to ensure a maximum pressure setting of 1340 kPa (195 psi). Attach nitrogen or air bottle hose assembly to the extinguisher fill connection.

STEP #11: Open nitrogen or air bottle discharge valve. Depress extinguisher discharge handle and hold down until extinguisher gage reads 1340 kPa (195 psi). Release handle and close nitrogen or air bottle Discharge valve and install safety pin.

STEP #12: Remove nitrogen or air bottle hose assembly and extinguisher discharge fill connection fitting.

STEP #13: Retrieve and inspect extinguisher hose and horn assembly. Visually check threads for wear. (Check with thread depth gage at least quarterly). Check O-ring for wear and lightly coat with lubricant as required.

STEP #14: Re-attach hose and horn assembly hand-tight. Refill procedures are complete.